NISAC

The Generic Cities Project

The National Infrastructure Simulation and Analysis Center (NISAC) provides advanced modeling and simulation capabilities for the analysis of critical infrastructures and their interdependencies, vulnerabilities, and complexities. These capabilities help improve the robustness of our nation's critical infrastructures by aiding decision makers in the areas of policy analysis, investment and mitigation planning, education and training, and near real-time assistance to crisis response organizations.

The Department of Homeland Security's (DHS) Information Analysis and Infrastructure Protection (IAIP) Directorate sponsors the NISAC program. NISAC is a core partnership of Sandia National Laboratories (SNL) and Los Alamos National Laboratory (LANL). NISAC integrates the two laboratories' existing expertise in modeling and simulation to address the nation's potential vulnerabilities and the consequences of disruption among our critical infrastructures.

The Generic Cities Project provides approaches for developing scalable disaggregate models of functioning infrastructures in urban infrastructures when: (1) there are severe time constraints (quick turnaround is required); (2) general guidelines (normative properties or policies) applicable across regions are desired; or (3) generic information for specific localities and situations must be generated when detailed data is not available.

Another function of this module is to develop generic algorithms that can be used to solve basic measurement and analysis problems for different infrastructure networks.

Other research efforts have modeled these types of social behaviors by assuming that large numbers of people act in the aggregate like a fluid, whose behavior is governed by differential equations solvable on a computer. Instead, the UIS models the "disaggregated" behavior of each of the individuals in a city, county, state, or country. The UIS "re-aggregates" the individual behaviors by summing over them. The UIS models the behavior not of real people but of synthetic individuals who, in the aggregate, are statistically identical to a real population. This feature makes the UIS modeling "normative."

The UIS serves as a disaggregate, normative modeling framework for developing and integrating the high-resolution Generic Cities Project (Figure 1). The UIS and the Generic Cities Project share information at the individual/location level through their respective UPMoST modules.

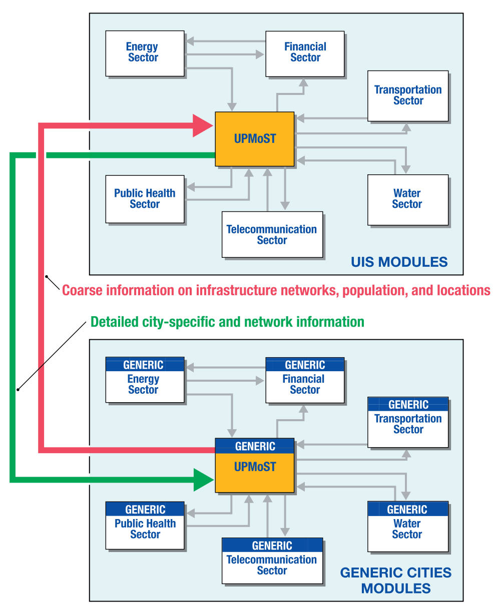

Figure 1. Shown are the information paths (red and green arrows) between the Generic Cities Project and the UIS, which consists of seven modules that model urban transportation, telecommunications, public health, energy, financial and water-distribution infrastructures and their interdependencies.

The results obtained by microscopic, high-resolution simulations, such as UIS, can be re-aggregated to construct macroscopic measures. Microscopic representations allow planning analysts to define very detailed scenarios during studies. Such detailed representation of scenarios is necessary to obtain non-linear system behavior and thus high-fidelity results.

Key Features

- Provides generic high-resolution modeling in the UIS framework.
- Identifies and incorporates publicly or easily available information sources into UIS technologies, methods, and practice. Provides methods for measuring and characterizing structural and cultural properties of complex infrastructure and social networks.
- Provides fast and provable algorithms for computing complex measures over very large social interaction networks.
- Uses efficient methods for combining commercial and publicly available data sets for constructing complex infrastructure and social networks.

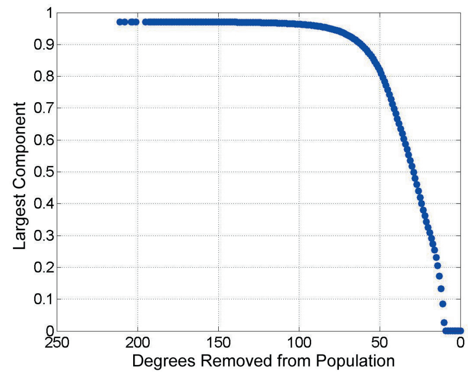

Figure 3. (above) During a day, if person A comes into direct contact with person B, the two people are separated by one link If that same day, person B comes into direct contact with person C, A and C are separated by two links, and so on. A "component" in a given population is a group of people who come into direct or indirect contact with each through any number of links during a day. In a city, for example, there is one large component that includes most of the residents and a few smaller components, including "loners." A person's "degree" is the number of other people that person comes into direct or indirect contact with during the day. This plot shows the size of the largest component (compared to the total size of the population) as the high-degree people are removed from the population. Even when all the people who come into contact with more than fifty other people are removed, the largest component still comprises 80% of the city's residents. The result has important implications for disease and information transmission in large urban areas.

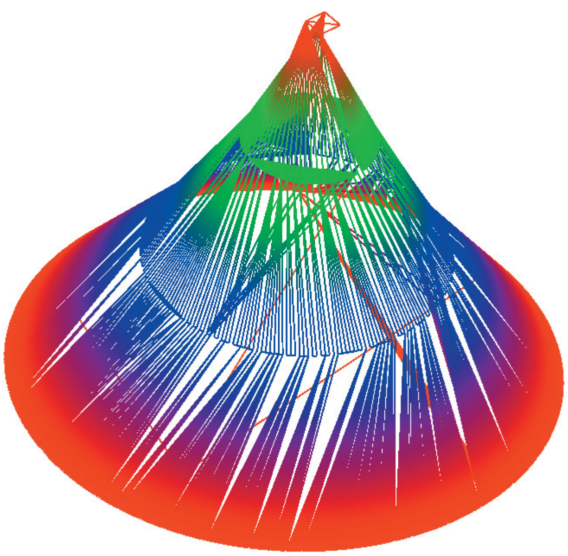

Figure 2. (left) The four vertices of the small square at the apex of this cone can represent, for example, four family members living in the same house. During the day, each family member meets other people (new contacts are represented by green lines), who in turn meet other people (blue lines), who in turn meet other people (red lines). The cone of lines is the family members' social contact network for a "length of path" equal to three. For a city the size of Portland, Oregon, nearly any two people have a length of path equal to seven at most. This result has important ramifications for the societal functions and spread of disease simulated by various NISAC modules.

Contacts:

Jon MacLaren
DHS-IP
(202) 282-8719
e-mail: jon.m.maclaren@dhs.gov

Randy E. Michelsen
Los Alamos National Laboratory
(505) 665-1522
e-mail: rem@lanl.gov

November 2004
LA-UR-04-8006